SECTION 2

PROJECT OVERVIEW AND OBJECTIVES

PROJECT OVERVIEW

In concept bioreactor landfills are designed to accelerate the biological stabilization of landfilled waste through increased moisture addition and other management techniques or procedures so as to enhance the microbial decomposition of organic matter. (Reinhart and Townsend, 1998). If the waste mass (or portions thereof) stabilizes more quickly than it would under conventional landfill operations, then certain benefits are anticipated.

Anticipated benefits include, that the receiving cell might accept more waste sooner and therefore the overall bioreactor landfill capacity should be greater. Enhanced waste stabilization should reduce the potential for future environmental problems because the generation and subsequent removal of high-strength leachates occurs earlier in the life of the leachate collection system and landfill liner. Landfill bioreactors may also improve the capture performance for landfill gas energy recovery projects through compressing the time during which methane generation is suitable for energy recovery concurrent with increased methane yields per unit of time. (Green, et al. 2000). Potential concerns of bioreactor technology currently include: the method of fluid addition; whether conventional landfill cell liners can sufficiently contain the increased fluid content; the amount of air space within these landfills; methods of determination of both moisture content and air space; and the effect on any fugitive gas emissions. Considering the potential environmental and economic benefits of bioreactor operations, there is great interest in this technology.

The purpose of this project is to test two types of landfills as bioreactors through the design, construction, and long-term operation of full-scale landfill cells. These two types of landfill, termed Facultative Landfill Bioreactor (FLB) and the Aerobic-Anaerobic Landfill Bioreactor (AALB), will each be compared to conventional landfilling techniques (Control). The initial objective of the project was to assess which parameters should be monitored in addition to those already monitored in conventional Subtitle D landfills, should either of these models, or a derivative thereof, be adopted as a standard method for landfill operation.

Rationale for Facultative Landfill Bioreactor

The Facultative Landfill Bioreactor (FLB) is based on a patent held by Waste Management, Inc. (U.S. Patent No.: US 6,398,958 B1, June 4, 2002). The patented process is a method by which the ammonia in the landfill leachate collected from the FLB is sequentially nitrified ex situ and then returned to the landfill where it is denitrified, resulting in a net loss of nitrogen from the landfill. The methodology was developed to control the cycling of inorganic nitrogen present in the landfill waste material and leachate. This aspect of control typically has not been addressed in previous bioreactor studies and has resulted in high concentrations of ammonia in the leachate, leading to disposal problems and potential microorganism poisoning where the leachate is recirculated.

The process includes a method to manage the nitrogen cycle in the bioreactor landfill by the biological conversion of ammonia in the leachate to nitrate and nitrite. The nitrate/nitrite-rich leachate is returned to the landfill, thus promoting landfill biological stabilization and reducing or eliminating the need for ex-situ leachate disposal.

The reduction in leachate ammonia levels is achieved by withdrawing the leachate from the landfill and directing it into an attached growth nitrification unit. There the leachate will remain in contact with nitrification microorganisms, attached to fixed organic or inorganic substrates, for sufficient time to nitrify a minimum of 50 percent of the ammonia. The nitrified aqueous product is then returned to the landfill or to another landfill where it is biologically denitrified in situ, producing nitrogen gas. The denitrification step occurs in landfills undergoing either aerobic or anaerobic decomposition.

As discussed herein, this project is designed to test and compare the FLB method through the traditional existing landfill by injecting nitrate-containing leachate into landfill cells. This approach is based on two premises. The first is that the addition of leachate will moisten and promote degradation of the waste. The second is that microorganisms present in the landfill waste use nitrate in the leachate as a terminal electron acceptor for anaerobic metabolism. As nitrate containing liquid moves through the upper sections of the FLB, denitrifying bacteria will convert nitrate to dinitrogen gas. This transformation of nitrate-nitrogen to gaseous nitrogen should result in the net loss of gaseous nitrogen from the landfill. Comparisons will be made to a conventional landfill cell not receiving moisture addition (i.e., this project has no representative control where leachate addition is made under conditions of no enhancement of the leachate with nitrate).

Rationale for Aerobic-Anaerobic Landfill Bioreactor

The Aerobic-Anaerobic Landfill Bioreactor (AALB) is based on a patent held by Waste Management, Inc. (U.S. Patent No.: US 6,283,676 B1, September 4, 2001). This patent (titled "The Sequential Aerobic/Anaerobic Solid Waste Landfill Operation Patent") includes the design and apparatus used to build the AALB with the primary objective of increasing degradation of municipal solid waste to increase landfill density and hence capacity. The method design also aims to improve the quality of the degradation by-products including leachate and landfill gas, and reduce landfill gas fugitive emissions. The patented process described the method for constructing the AALB and applying sequential aerobic and/or anaerobic operations to the waste mass in sequential waste lifts.

In brief, the design involves placement of the first lift of waste material on top of the leachate withdrawal piping, followed by placement of the first piping layer on the top surface of the first lift; then placement of a second lift of waste on top of the first piping layer, followed by a second lift having a second lift top surface and placement of a second piping layer on the top surface of the second lift; and finally introducing air into the second lift using the first piping layer. Operation of this method is described in the patent.

As discussed herein, the project is designed to test and compare the AALB approach through the use of new landfilled wastes. The newly placed waste is treated aerobically, similar to composting, by injecting air into the waste for approximately 30 to 60 days. After aeration is discontinued, the waste is moistened with liquids, and anaerobic conditions are rapidly established. In Section 4, comparisons are made to Unit 7.3, a conventional landfill cell not receiving air addition or moisture addition (Control).

Project Setting

The Outer Loop Recycling and Disposal Facility (OLDRF) is located in Louisville, Jefferson County, Kentucky. The site, which has a total property area of approximately 782 acres, is located on the north side of Outer Loop Road, immediately west of Interstate Highway 65. The OLDRF is comprised of seven individual and separate landfill units, designated Units 1 through 7. Unit 1, Unit 2, Unit 3, and Unit 6 are inactive landfill units that are not receiving waste. Unit 4 is permitted as a construction and demolition debris (CD/D) landfill, and is an active unit. Unit 5 and Unit 7 are active permitted landfills and are the units of focus for this Bioreactor study. The Outer Loop Landfill is operated by Waste Management Inc. (WMI), and has been used for waste disposal for approximately 35 years. See Figure 2-1: Project Site Location Map.

The site is situated within the alluvial valley of the Ohio River; approximately nine miles southwest of river mile 614. The area is generally flat with elevations averaging 455 feet Mean Sea Level (MSL). The region is effectively enclosed by topographically elevated areas on the west, east and south. Elevations range up to 750 feet MSL in areas surrounding the site.

Topography and stream development in the area have been modified by construction and development activities of the region. Due to the flat topography, the clayey nature of the soil, and the relatively low elevation, the area is naturally poorly drained. To enhance surface drainage for the development of the region, several engineered drainage channels have been constructed in the area of the landfill. The channels drain toward the southwest, eventually discharging into the Ohio River. It has been observed that seepage of groundwater into the landfill occurs.

The average regional temperature is 14ºC, ranging from –4 to 31ºC. Average annual precipitation consists of 44.39 inches of rainfall, plus approximately 17.4 inches of snow. The number of precipitation days averages 125 per year, with 47 days being thunderstorms. Prevailing wind is from the south. Relative humidity varies throughout the day at an annual average of 58 to 76 percent. (Source: US Department of Commerce, National Climatic Data Center).

Project Ownership

The projects are under joint investigation by the U.S. Environmental Protection Agency (EPA) and Waste Management, Inc. through a 5-year Cooperative Research and Development Agreement (CRADA). The overall project is being managed, analyzed and operated by Waste

Management, Inc. at the Outer Loop Landfill located in Louisville, Kentucky. Personnel are made up of individuals from Outer Loop and the WMI BioSites program in Cincinnati, Ohio. The U.S. EPA is contributing to the management, oversight and analysis of the project. Table 2-1 provides a listing of the project participants and related project responsibilities.

TABLE 2-1. PROJECT PARTICIPANTS, AFFILIATION AND RESPONSIBILITIES

NAME	AFFILIATION	RESPONSIBILITY
Tony Barbush	WMI	Co-Principal Investigator; on-site operations
Morton Barlaz	North Carolina State University	Analytical measurements, quality assurance
David Burt	WMI	Oversight and quality assurance
David Carson	EPA	Co-Principal Investigator; project oversight
Greg Cekander	WMI	Program Owner; project oversight
Wendy Davis-Hoover	EPA	Co-Principal Investigator; project oversight
Charles Huber	Severn Trent Labs	Laboratory quality assurance
Douglas Goldsmith	Alternative Natural Technologies	Senior Scientist; sampling and analysis
Michael Goodrich	Microbial Insights	Manager; laboratory analyses
Roger Green	WMI	Co-Principal Investigator; field sampling oversight and database management.
Amy Haag	Severn Trent Labs	Manager; laboratory analyses
Gary Hater	WMI	Project Manager
Scott Jacobs	EPA	Quality Assurance Manager
Fran Kremer	EPA	Project coordination
Jim Markwiese	Neptune & Company, Inc.	Data validation
John Martin	EPA	Branch Chief; project oversight
Susan Thorneloe	EPA	Scientist; landfill gas and air emissions
Chuck Williams	WMI	Program Owner

State Approval

Approval for the AALB (constructed in Unit 7.4 A and B), and the FLB (retrofitted in Unit 5) was received from Commonwealth of Kentucky, Kentucky Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection in 2001 (Permit No. 056-00028). Approval for the FLB study was issued in January 2001. Approval for the AALB study was issued in October 2001.

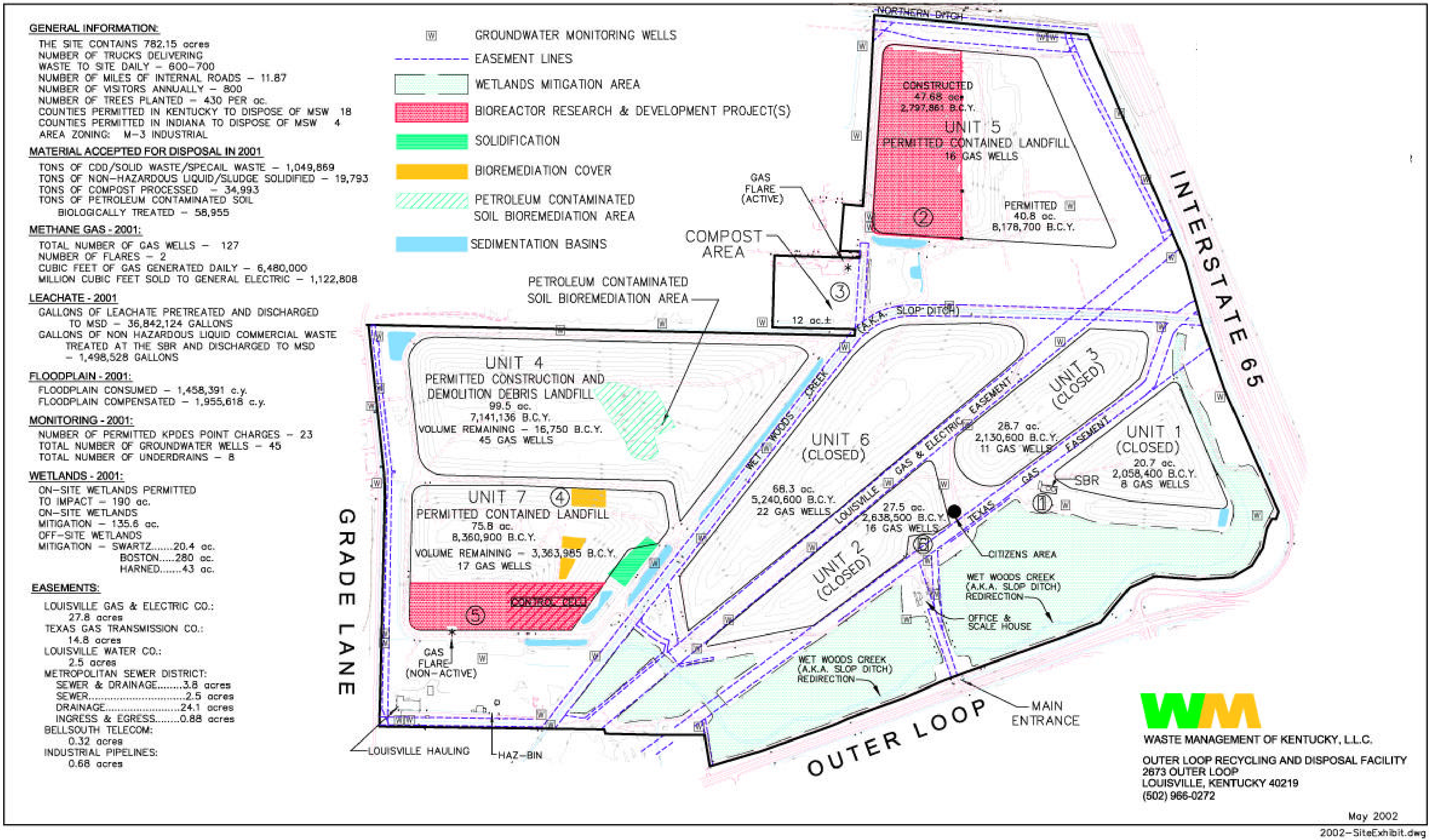

Figure 2-1. Project Site Location Map

PROJECT OBJECTIVES

The landfill research described herein involves two multi-year landfill bioreactor studies in comparison with control landfill cells. The FLB and AALB studies are underway and consist of separate and distinct landfill units, each composed of two paired cells. In contrast to most landfill bioreactor research conducted at the bench or laboratory scale, this demonstration project is a full-scale application of the stated bioreactor approaches and methods.

The overall project objectives for the landfill bioreactor studies at the Outer Loop Landfill Facility can be stated as:

- To engineer and install two alternative designs of large-scale bioreactors.
- To monitor sufficient parameters to understand the physical, chemical and biological activities and changes over time within the landfill bioreactors, with particular emphasis given to waste settlement, as well as the characteristics for in-place solid waste, leachate, and landfill gas.
- To compare and contrast the measured information with that of a conventional Subtitle D MSW landfill (dry entombment methodology) in order to evaluate differences due to the bioreactor treatments. But not necessarily to compare the two alternative designs.
- To incorporate statistical techniques to assess the effectiveness and protectiveness of the landfill bioreactor operational technique.
- To establish best practices and procedures required to operate landfill bioreactors.
- To establish the important and indicative parameters that should be monitored with respect to landfill bioreactor operations. (See discussion in Section 3 on Critical and Non-critical measurements).
- To obtain sufficient research data to enable improvements that might be applied to future bioreactors, both in an experimental capacity and ultimately as an alternative design and management method for future MSW landfills.

<u>QA/QC Procedures</u>

Quality assurance and quality control procedures are designed and incorporated into this investigation to ensure reliable analytical measurements of environmental samples in terms of typical data quality indicators. Required controls for precision, accuracy, method detection limits, completeness, comparability and representativeness are presented in Appendix C, the Quality Assurance Project Plan (QAPP). This document should be referred to for descriptions of QA/QC procedures.

Neptune and Company, Inc. was retained to performed data validation on selected sets of laboratory data for leachate and gas samples, including laboratory-generated data included in this report. As presented in Appendix C, observations and discrepancies in the project data were identified on a systematic basis. Subsequently, corrective steps were taken as warranted by the laboratory, Waste Management, and the EPA project team so as to make necessary adjustments and/or flag certain data points.

REPORTING

This Interim Report covers the period from the treatment cell initiations through April 2003. Monitoring is scheduled for a minimum period of the five-year contract life. A final report will be prepared and submitted at the conclusion of the project.